NEW RECORDS AND DISTRIBUTION OF AQUATIC INSECT HERBIVORES OF WATERMILFOILS (HALORAGACEAE: *MYRIOPHYLLUM* SPP.) IN MINNESOTA[1]

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ABSTRACT: A survey of 19 lakes in Minnesota and six lakes in Wisconsin, for the presence of watermilfoil herbivores, indicated the presence of three taxa: a weevil *Euhrychiopsis lecontei* (Dietz) (Curculionidae), a lepidopteran, *Acentria ephemerella* (Denis & Schiffermüller) (Pyralidae) and a midge *Cricotopus myriophylli* Oliver (Chironomidae). We located the weevil, *Euhrychiopsis lecontei,* at 13 sites in 10 lakes; 11 of these sites were in Minnesota. The midge, *Cricotopus myriophylli,* was found at eight sites in six lakes, including two sites in Wisconsin, and the moth, *Acentria ephemerella,* was found at five sites, including one site in Wisconsin. The weevil and caterpillar had been recorded previously in Wisconsin, but not in Minnesota. The midge has not been reported previously outside of eastern Ontario and British Columbia.

Eurasian watermilfoil *(Myriophyllum spicatum* L.*)* is an exotic aquatic weed that was introduced to North America between the late 1800s and the early 1940s (Aiken *et al.* 1979, Smith and Barko 1990). It is a major nuisance species in eastern North America, the Pacific Northwest and the upper midwest (Grace and Wetzel 1978, Aiken *et al.* 1979, Smith and Barko 1990). It was first reported in Minnesota in 1987 and now occurs in over 60 lakes and two streams in Minnesota (Exotic Species Programs 1993).

The nuisance impact of this plant is obvious from the continual and expensive efforts used to control it (Aiken *et al.* 1979). Recently, interest has increased in potential biological controls of Eurasian watermilfoil, and declines of the plant have been associated with populations of native and naturalized invertebrates which are known to be herbivores of Eurasian watermilfoil. These herbivores include a lepidopteran, a chironomid and a curculionid. The moth *Acentria ephemerella* (Denis & Schiffermüller) (= *Acentria nivea* (Olivier), see Passoa 1988), is a naturalized Pyralidae (Forbes 1938, Buckingham and Ross 1981) which consumes Eurasian watermilfoil (Buckingham and Ross 1981, Creed and Sheldon 1994a). The midge *Cricotopus myriophylli* Oliver, appears to be indigenous to North America (Oliver 1984, and personal communication) and consumes Eurasian watermilfoil and the native northern watermilfoil *(M. sibiricum* Komarov = *M. exalbescens* Fernald) (Kangasniemi and Oliver 1983, MacRae *et al.* 1990). The weevil *Euhrychiopsis lecontei* (Dietz) (= *Eubrychiopsis lecontei),* also consumes Eurasian and northern watermilfoils (Creed *et al.* 1992, Creed and Sheldon

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1993a, 1994a) and also appears to be indigenous to North America (O'Brien and Wibmer 1982, Creed and Sheldon 1994b). The caterpillar of *A. ephemerella* has been associated with Eurasian watermilfoil declines in Ontario (Painter and McCabe 1988). The larvae of the midge *C. myriophylli* have been associated with Eurasian watermilfoil declines in British Columbia (Kangasniemi and Oliver 1983, MacRae and Ring 1993, Kangasnemi *et al.* 1993). Adults and larvae of the weevil *E. lecontei* have been associated with declines of Eurasian watermilfoil in Vermont (Creed *et al.* 1992, Creed and Sheldon 1993b, 1994a) and British Columbia (Kangasniemi 1983).

To the best of our knowledge, there are no published reports of the occurrence of these insects in Minnesota and no specimens were previously present in local collections (R. W. Holzenthal, personal communication). *Cricotopus myriophylli* has only been reported from Ontario and British Columbia (Oliver 1984, and personal communication). *Acentria ephemerella* and *E. lecontei* have been reported to occur in Wisconsin (Buckingham and Ross 1981, Lillie 1991), however we are not aware of reports of *A. ephemerella* west of Wisconsin and reports of *E. lecontei* have been restricted to the North East, Iowa, Wisconsin, Alberta, British Columbia and Washington.

The aim of this paper is to provide new state records for these organisms in Minnesota and to provide a brief description of their distribution and occurrence in the 25 lakes we sampled in 1992 and 1993. Because these invertebrate herbivores have been associated with declining populations of the nuisance aquatic plant Eurasian watermilfoil (*M. spicatum)* in other regions, and because there is a paucity of information on macrophyte herbivores (Newman 1991), their occurrence is of interest to ecologists and biological control investigators as well as to taxonomists.

METHODS

We sampled 25 sites (lakes or bays) in 19 lakes in Minnesota and six additional sites (lakes) in Wisconsin for the presence of milfoil herbivores. Most of these sites were sampled once in August and September 1992; however, eight sites in Minnesota and two in Wisconsin were sampled at least twice, in both 1992 and 1993. At all but one site, invertebrates were sampled using a $0.1m^2$ quadrat sampler operated by a SCUBA diver; plants were clipped at the sediment interface and all plants and invertebrates collected within $0.1m^2$ area were placed into a sealable plastic bag. Generally 6-12 samples were collected at each site. At 11 sites, including the sites sampled in both 1992 and 1993, invertebrates were also collected with a Mobile Invertebrate Sampler (Creed and Sheldon 1993b), which is a $0.2m^2$ submersible tube; plants were clipped at the sediment interface and a 500 μm mesh lid was placed on the end of the tube before it was lifted to the surface. At each site, divers also examined plants for the presence of herbivores and additional samples of plant

material were collected in shallow water along the shore. At one site, Bierbrauer Pond, no quantitative sampling was used, but the pond was visually surveyed for 4 hrs by two snorkelers who collected and examined plants.

Samples were returned to the lab and refrigerated until processing, or after 30 days they were preserved in 10% formalin. Samples were rinsed well and invertebrates collected in 420 μm mesh. For the $0.1m^2$ quadrat samples, stems were examined and clinging and endophytic organisms were removed. Invertebrates were sorted at 8X under a dissecting scope. A subsample of chironomids from each site was mounted and identified by Bozena Kuklinska. Potential control agent identifications were verified by experts for all initial locations and most of our site records. Weevil identifications were verified by Charles W. O'Brien (Florida A & M University, Tallahassee, FL), caterpillar identifications were verified by Steven Passoa (USDA, APHIS PPQ, Reynoldsburg, OH) and *Cricotopus* identifications were verified by Don R. Oliver (Centre for Land and Biological Research Resources, Ottawa, ON).

Specimens upon which these records are based are housed in the University of Minnesota Insect Collection, St. Paul, MN 55108, U.S.A., and additional vouchers have been deposited with the above mentioned taxonomic experts.

RESULTS AND DISCUSSION

We located milfoil herbivores at over half of the sites we sampled (Table 1). We located the weevil *E. lecontei* at 13 sites in 10 lakes; 11 of these sites were in Minnesota. All but three sites sampled had Eurasian watermilfoil; Gull Lake, Christmas Lake and Bierbrauer Pond, WI, had no Eurasian watermilfoil, but did have northern watermilfoil. Gull and Christmas Lakes had populations of *E. lecontei.* We found no weevils in Bierbrauer Pond, WI, noted by Lillie (1991) to contain *E. lecontei* with northern watermilfoil, even though we surveyed the pond extensively. We did collect *E. lecontei* from Devil's and Fish Lakes, WI, both of which had verified populations of the weevil from the early 1980s (R.A. Lillie, WI DNR, personal communication).

The midge, *C. myriophylli* was found at eight sites in six lakes, including two sites in Wisconsin (Table 1). These are the first verified records of this species outside of Ontario and the Pacific northwest. The moth, *A. ephemerella,* was found at only five sites, all but one in Minnesota (Table 1).

Our observations suggest that although they have not been reported previously from Minnesota, all three species are likely widespread. Both *E. lecontei* and *C. myriophylli* appear to be native to North America and have not been reported in Europe. Although they usually seem to be associated mostly with the exotic Eurasian watermilfoil, it is likely that they occurred in Minnesota before the introduction of Eurasian watermilfoil, first observed in 1987. We collected *E. lecontei* from *M. sibiricum* in Gull Lake (46°25'N, 94°22'W),

which is over 30 km from the nearest *M. spicatum* infestation, and 150 km northwest of common infestations. In the fall of 1994, we also collected *E. lecontei* from *M. sibiricum* in Squaw Lake (47°16´N, 95°14´W; T143N, R36W, S5), which is over 120 km from the nearest *M. spicatum* infestation, and 250 km northwest of common infestations. These records, along with records from *M. sibiricum* in Alberta (Creed and Sheldon 1994b), where *M. spicatum* does not yet occur, suggest that *E. lecontei* is native to Minnesota. Similarly, although we only collected *C. myriophylli* on *M. spicatum,* it is likely that *C. myriophylli* also is native to Minnesota, given the disjunct distribution of previously reported occurrences (British Columbia and southern Ontario). Kangasniemi *et al.* (1993) suggested that *C. myriophylli* is native to British Columbia and its original host plant is *M. sibiricum* based on their findings of populations on *M. sibiricum* in regions of British Columbia where *M. spicatum* does not yet occur. One lake in which we found *C. myriophylli* (Long Lake), had just been identified in 1992 as having *M. spicatum.* It is not possible to tell if the pyralid, *A. ephemerella,* was in Minnesota prior to the introduction of Eurasian watermilfoil because *A. ephemerella* appears to be exotic to North America (Forbes 1938, Buckingham and Ross 1981) and it was found on *M. spicatum* in the five lakes where it occurred. More sampling of lakes without Eurasian watermilfoil would be useful to determine if these herbivores are expanding their distribution with Eurasian watermilfoil or in response to Eurasian watermilfoil. Such studies also would help clarify the original hosts of these species. *Acentria ephemerella* appears to be a generalist herbivore (Buckingham and Ross 1981), but both *E. lecontei* and *C. myriophylli* appear to be specialists and have been reported to feed and develop only on Eurasian and northern watermilfoils (Creed and Sheldon 1993a, 1994b, MacRae and Ring 1993).

Although quantitative data were collected using the methods outlined above, our initial observations of the three taxa were often made serendipitously during searches of large quantities of milfoil in shallow water, snorkeling or examining plant material collected during surveys of the plant community from our boat. We suspect that these organisms are somewhat patchy in their distribution, both temporally and spatially. For example, the initial observations of *E. lecontei* in Lakes Otter, Auburn and Minnewashta were made during the collection of plants, not from quantitative samples. Year to year variation in abundance of weevils was also apparent, although the extent to which this occurs will only be established by more long term monitoring. For example, in our 1992 sampling effort (22 lakes), *E. lecontei* was only found in Lake Auburn, Gideons Bay (Minnetonka), Devils Lake and Fish Lake. In 1993, *E. lecontei* was found at 10 of 12 sites sampled. Similarly, damage to milfoil meristems typical of that produced by *C. myriophylli* was observed at Otter Lake, but we have not been able to find the midge at that site.

Numbers of the herbivores have been low at most sites. Only one $0.1m^2$ quadrat sample yielded more than one *Acentria* larva (three were found in one sample from Lake Auburn), however, *E. lecontei* densities have averaged > $20/m^2$ at several sites. Because of this variability, we wish to emphasize that the fact that we have not collected specimens of these taxa at some sites does not imply that they do not occur there.

Table 1. Lakes sampled for the occurrence of potential milfoil herbivores. [1]Year in which the occurrence of *M. spicatum* was first recorded (None = not known to be present). *Myriophyllum spicatum* is not known to occur in Gull Lake (*M. sibiricum* is abundant) and the nearest known *M. spicatum* population is approximately 30 km away. [2]Township, Range and Section of sampling sites. [3]A minor infestation of *M. spicatum* was found and chemically treated in 1992 and no *M. spicatum* has been seen since. Organisms collected in Gull and Christmas Lakes were taken from *M. sibiricum*. [4]Mississippi River sites. *These identifications have not been verified by a taxonomic specialist. All other identifications have been verified.

LAKE NAME	COUNTY	STATE	M.s. obs.[1]	LOCATION[2]	Herbivore
Auburn	Carver	MN	1989	T116N;R24W;S10	E.l.,A.e.
Bierbrauer	St. Croix	WI	None	T31N;R17W;S4	
Calhoun	Hennepin	MN	1989	T28N;R24W;S5	
Cedar	Hennepin	MN	1990	T29N;R24W;S29	E.l.
Christmas	Hennepin	MN	1992[3]	T117N;R23W;S35,36	E.l.
Clearwater	Wright	MN	1989	T121N;R27W;S17	
Devils	Sauk	WI	≤1976	T11N;R6E;S13	E.l.,C.m.
Fish	Dane	WI	1967	T9N,R7E;S3	E.l.
Green	Chisago	MN	1990	T33N;R21W;S13	
Gull	Cass	MN	None	T134N;R30W;S24,25	E.l.
Independence	Hennepin	MN	1989	T118N;R23,24W;S7,12	
Lake of the Isles	Hennepin	MN	1988	T29N;R24W;S32,33	
Long	Hennepin	MN	1992	T118N;R23W;S34,35	C.m.
Mallalieu	St. Croix	WI	<1990	T29N;R19W;S18,19	C.m.*,A.e.*
Minnetonka					
Gideons Bay	Hennepin	MN	1987	T117N;R23W;S27	E.l.
Grays Bay	Hennepin	MN	1987	T117N;R22W;S8	E.l.*,C.m.
Halsted Bay	Hennepin	MN	1987	T117N;R24W;S34	
St. Albans Bay	Hennepin	MN	1987	T117N;R23W;S26	
Shady Is	Hennepin	MN	1987	T117N;R23W;S30	C.m.
Smiths Bay	Hennepin	MN	1987	T117N;R23W;S10,11	E.l.,C.m.*
Veterans Bay	Hennepin	MN	1987	T117N;R23W;S23	E.l.
Minnewashta	Carver	MN	1989	T116N;R23W;S5	E.l.,C.m.,A.e.*
Onalaska[4]	La Crosse	WI	≤1987	T17N;R7W;S31	
Otter Lake	Anoka/Ramsey	MN	1989	T30N;R22W;S3,35	E.l.
Parker	Hennepin	MN	1991	T118N;R22W;S28	
Sarah	Hennepin	MN	1990	T118N;R24W;S2	A.e.*
Spring[4]	Buffalo	WI	≤1989	T20N;R12W;S17,20	
Vadnais	Ramsey	MN	1989	T30N;R22W;S30	E.l.*
Virginia	Carver	MN	1988	T116N;R23W;S6	A.e.
Waverley	Wright	MN	1991	T119N;R26W;S32	
Zumbra	Carver	MN	1989	T116N;R24W;S2	C.m.

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BOOK RECEIVED AND BRIEFLY NOTED

HOST-PLANT SELECTION BY PHYTOPHAGOUS INSECTS. E.A. Bernays and R.F. Chapman. 1994. Chapman & Hall. 312 pp. $24.50 ppbk.

This book focuses on the behavior of host-plant selection by plant-feeding insects. It describes the patterns of host use, the chemical features of plants that determine host selection, the physiology of insect sensory systems, and the insect behaviors, with an emphasis on mechanisms. The book also discusses genetic variability and the effects of experience, and concludes with a review of the evolution of host-plant ranges.